Macrogeomorphology and erosional history of the post-orogenic Pyrenean mountain belt

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Declaration

The results of this thesis have not been submitted for the examination of any other degree or qualification. The observations and conclusions presented in this volume are the result of my own studies except where cited or acknowledged otherwise.

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Abstract

Considerable work to date on orogenic systems has focussed on active orogens, whereas relatively little research has looked at inactive, post-orogenic systems. This study begins to redress this balance by considering the post-orogenic Pyrenean mountain belt. The relative importance of the controls of tectonics, lithology and climate on the resultant geomorphology of the post-orogenic system are considered, as well as quantifying the degree and timing of post-orogenic exhumation. This is achieved through the use of digital elevation data, field observations and low temperature thermochronology.

Extraction of morphometric parameters from digital elevation data at a catchment scale reveals a north-south asymmetry within the Pyrenees, with northern catchments having steeper slopes and lower minimum elevations than their southern counterparts. This is attributed to an inherited tectonic control, with the original asymmetric form that was developed during active orogenesis being preserved through post-orogenic erosion. The distribution of erosion-resistant crystalline massifs within the Axial Zone of the Pyrenees provides a first order control on the position of the principal drainage divide. This resistance to erosion compared to the surrounding lithologies allows the massifs to define the high elevations within the chain. Climate has also played a role, with an enhanced glaciation on the northern side of the orogen brought about by orographic precipitation and reduced solar radiation. This has resulted in glaciation in northerly catchments reaching lower elevations than their southerly counterparts and permitting glaciers to extend further into the foreland in the north than those in the south during larger glaciations.

Apatite fission track and apatite (U-Th)/He thermochronometers and associated thermal modelling document an asymmetry in the exhumation and erosional history of the Pyrenees. Results show that vertical profiles in northerly draining catchments record rapid exhumation at 30 Ma, with 1 km or less of exhumation after this time. In contrast, samples to the south of the main drainage divide, whilst also showing rapid exhumation at around 30 Ma, show considerably more exhumation after this time (~2.5 km). Therefore, these thermochronometers also document the transition from a syn- to a post-orogenic system recording a gradual, diachronous shutdown across the orogen. This evidence suggests that some isolated regions of the orogen remained active after 20 Ma and possibly as late as 10 Ma, considerably later than previously documented. No evidence is recorded for an acceleration in erosion related to climate change in the last 4 Ma. Modelling work has also highlighted the importance of evolving topography and the associated deformation of isotherms that influence thermochronometric analysis in mountainous terrain.

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Abbreviations

The following abbreviations are used in this thesis

Ma	Millions of years ago
Myr	Millions of years
GIS	Geographical Information System
DEM	Digital Elevation Model
DTM	Digital Terrain Model
TIN	Triangular Irregular Network
AML	Arc Macro Language
DTED	Digital Terrain Elevation Data
DCW	Digital Chart of the World
VAT	Value Attribute Table
DALR	Dry Adiabatic Lapse Rate
SALR	Saturated Adiabatic Lapse Rate
HCM	Hercynian Crystalline Massif
ELA	Equilibrium Line Altitude
T_c	Closure Temperature
AFT	Apatite Fission Track
ZFT	Zircon Fission Track
AHe	Apatite (U-Th)/He Thermochronometer
PRZ	Partial Retention Zone
PAZ	Partial Annealing Zone
AER	Age-Elevation Relationship

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